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Twerdochlib

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(54) **TURBINE BLADE FOR MONITORING BLADE VIBRATION**

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G01H 9/00 (2006.01)

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(58) **Field of Classification Search** 73/655, 73/660, 593

See application file for complete search history.

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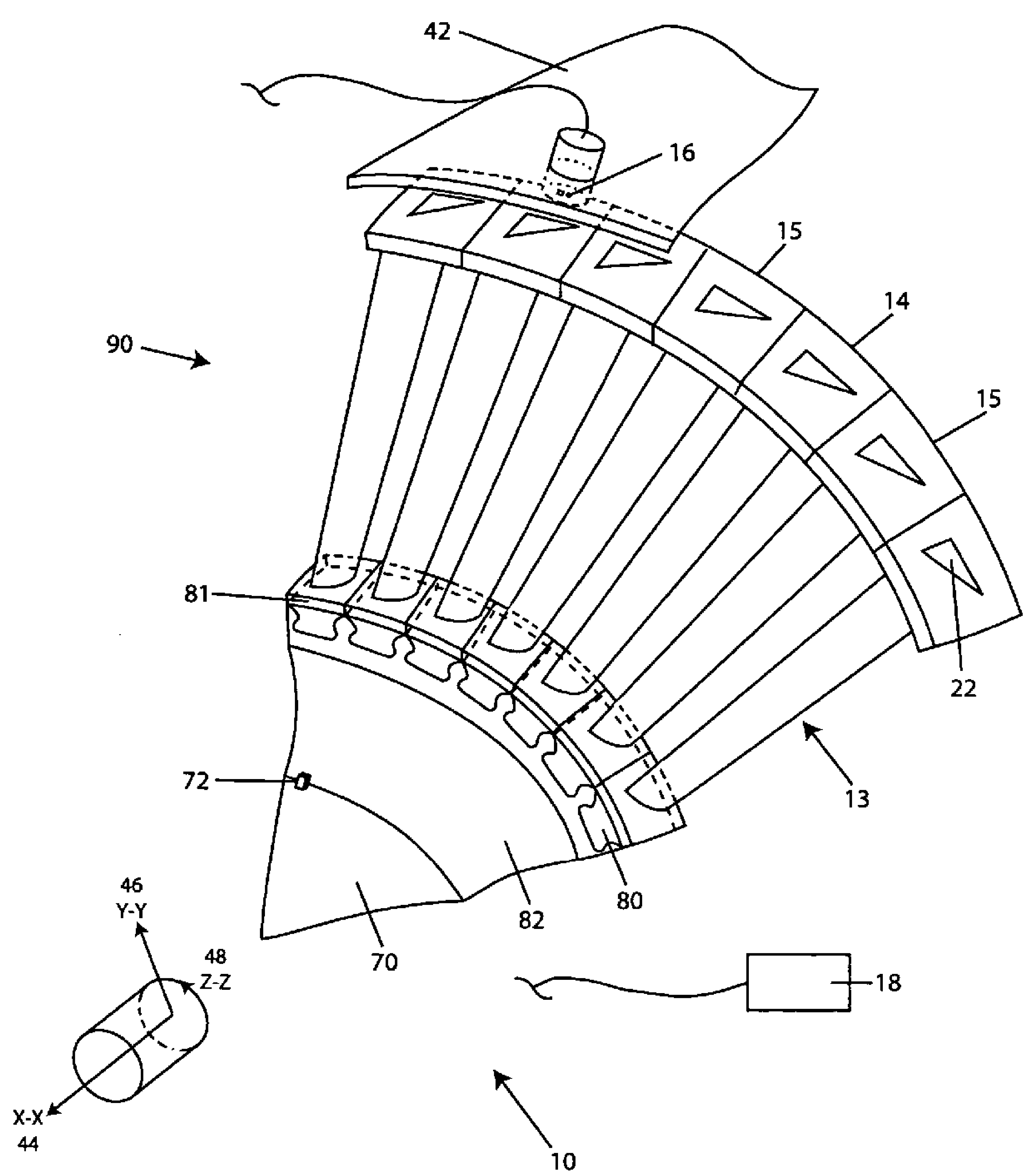
Primary Examiner — J M Saint Surin

(57) **ABSTRACT**

The claimed invention provides a blade vibration measuring system comprising a blade, a transmitter, a target with non parallel edges located on the blade shroud and a receiver. The present invention also provides a blade adapted for measuring blade vibration. Furthermore, the claimed invention provides a method for monitoring blade vibration.

29 Claims, 5 Drawing Sheets



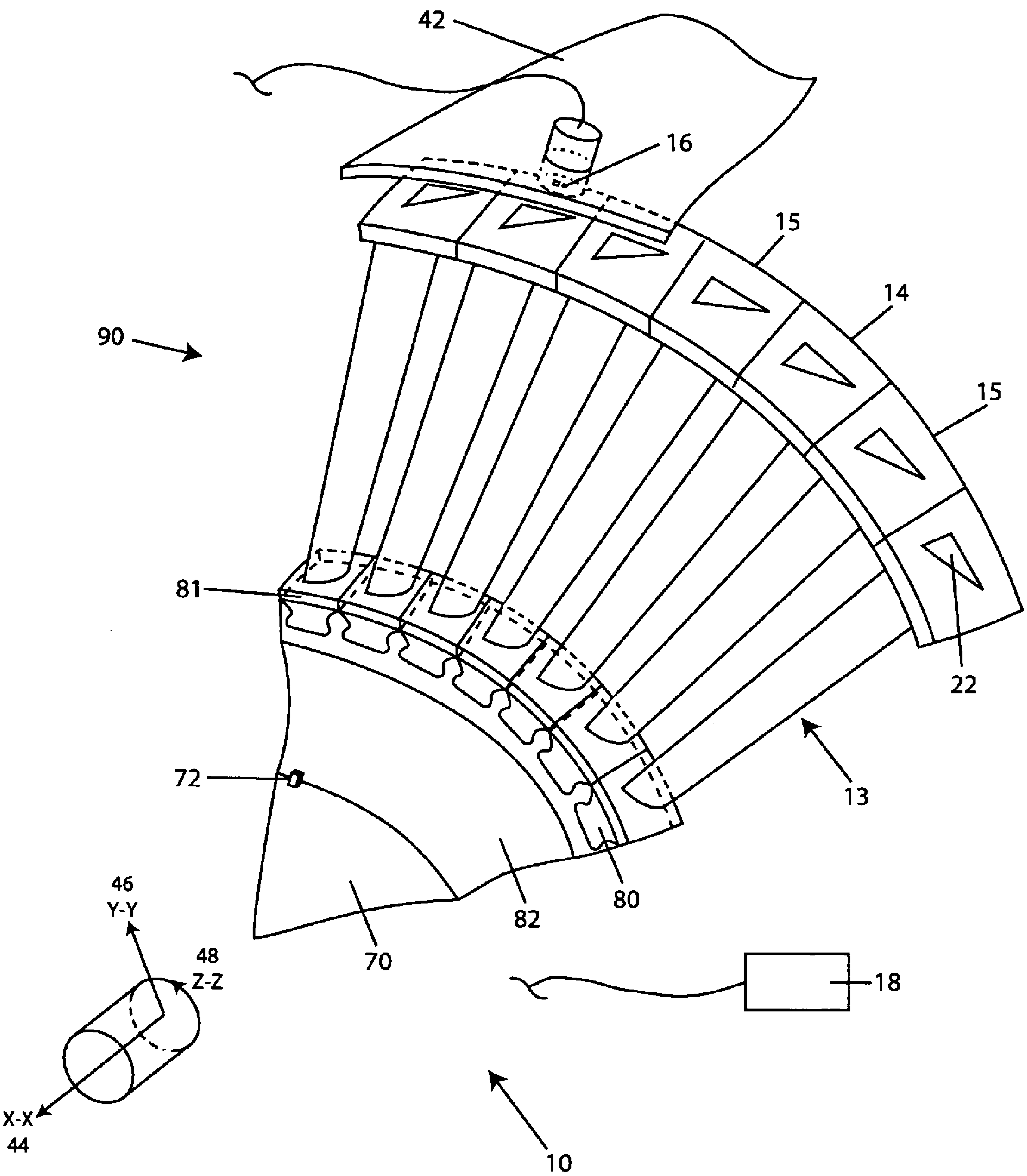


Figure 1

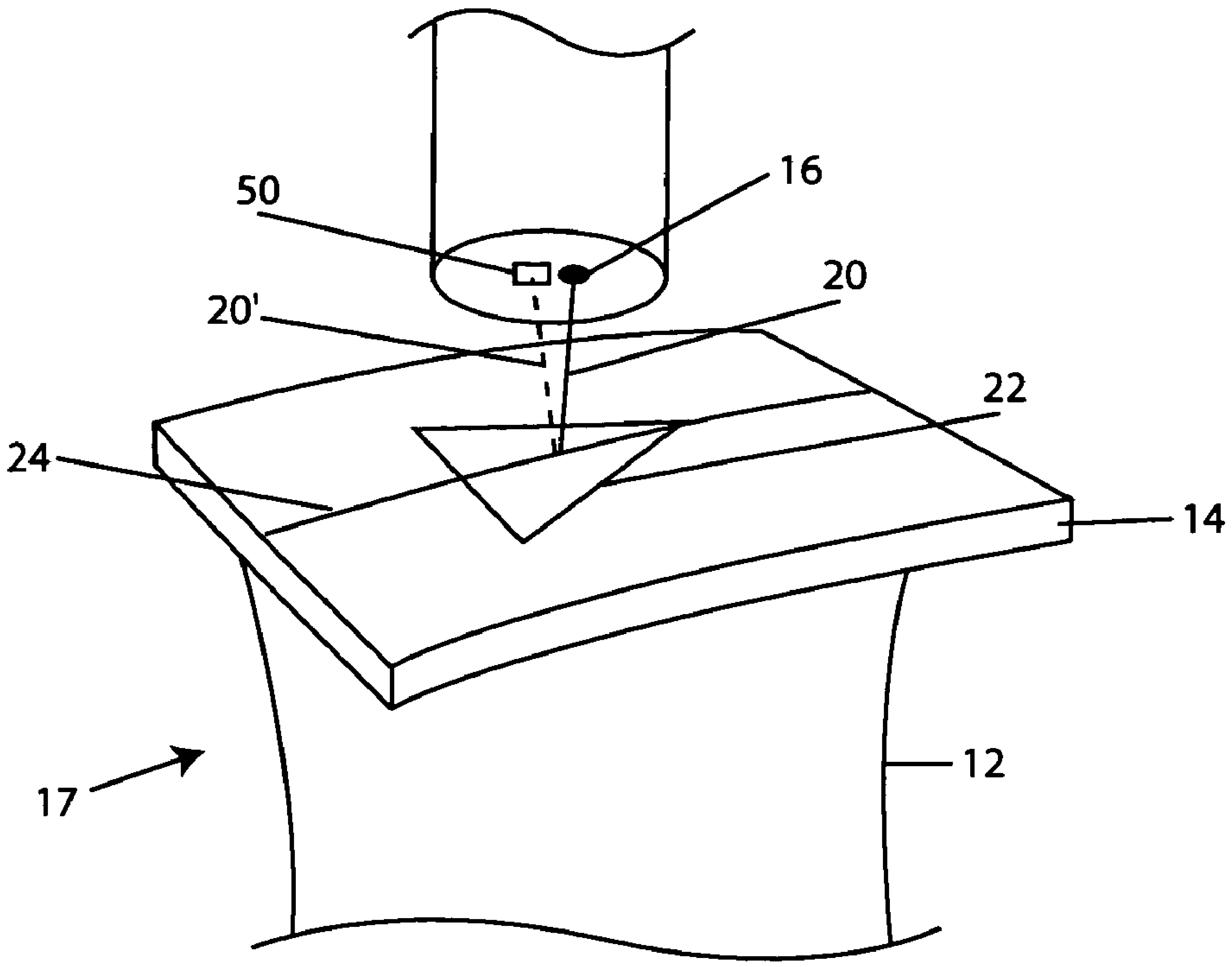


Figure 2a

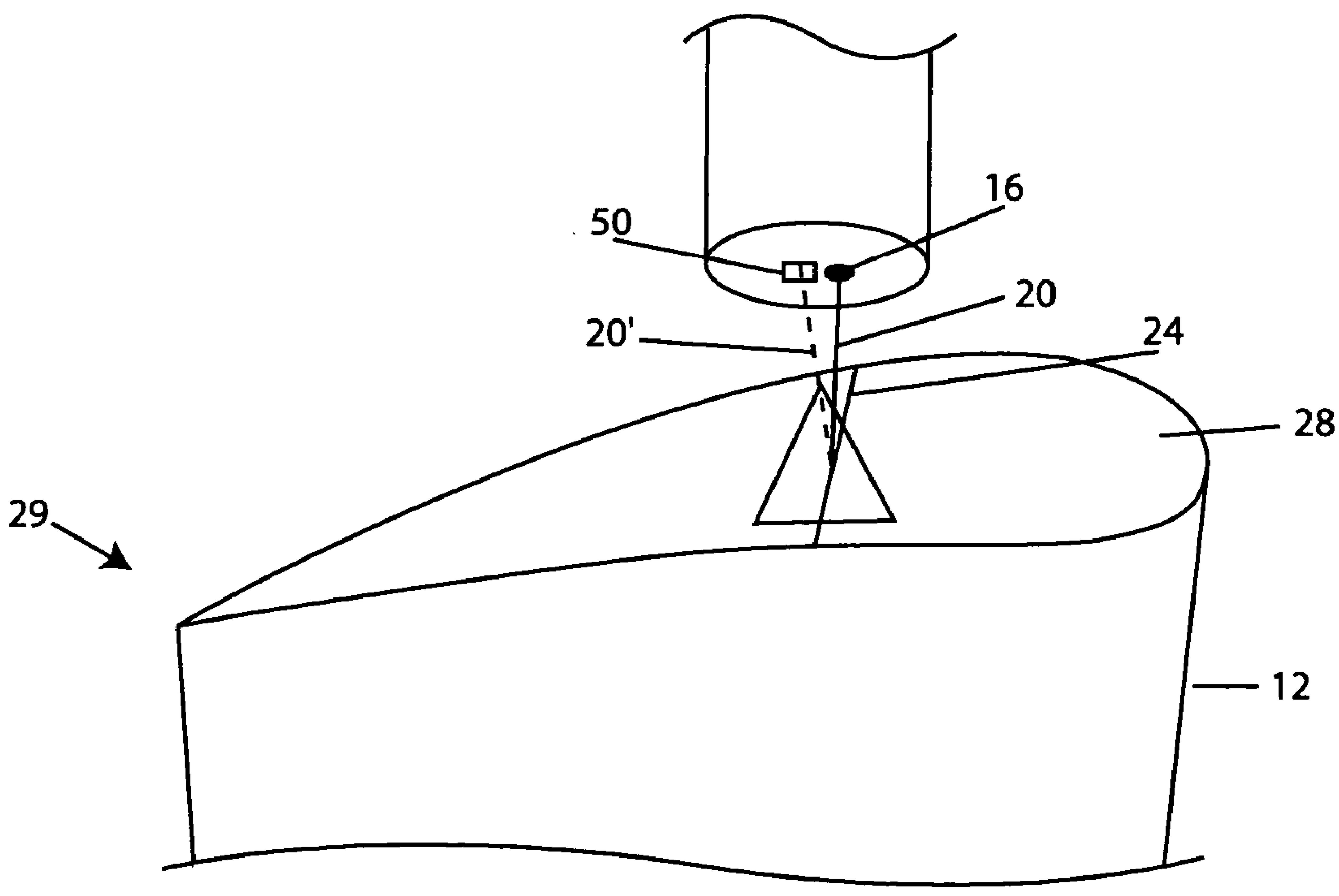


Figure 2b

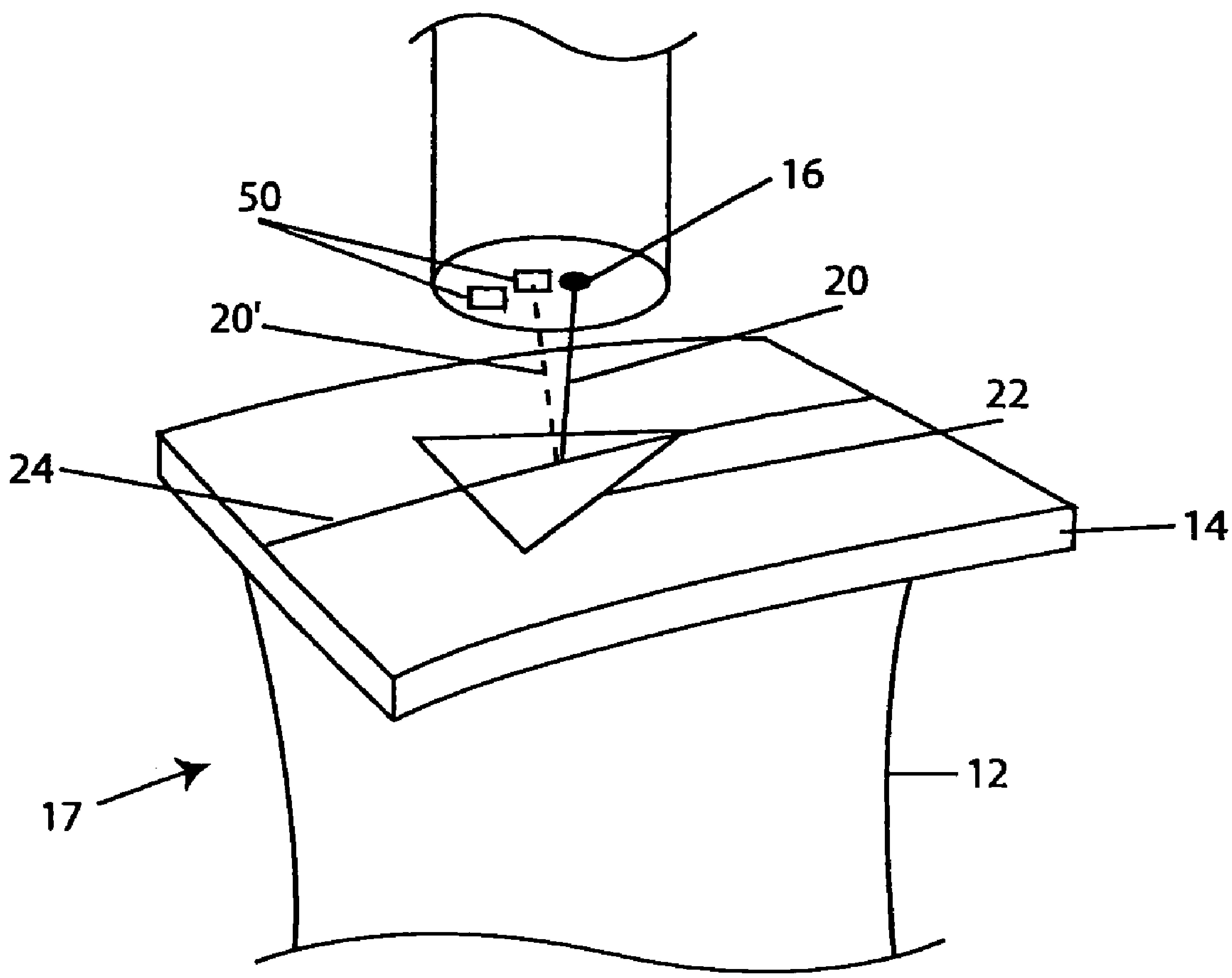


Figure 2c

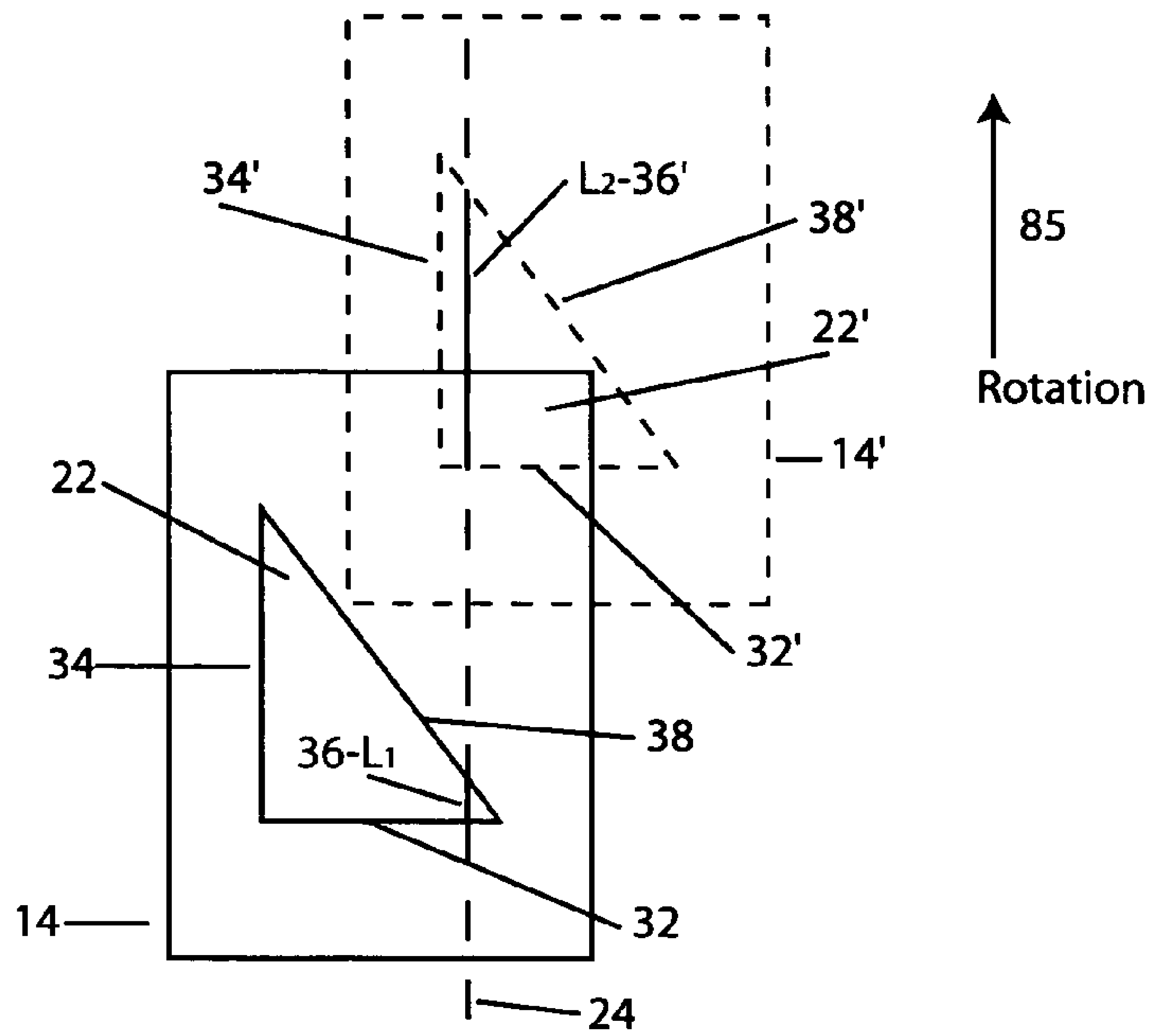


Figure 3a

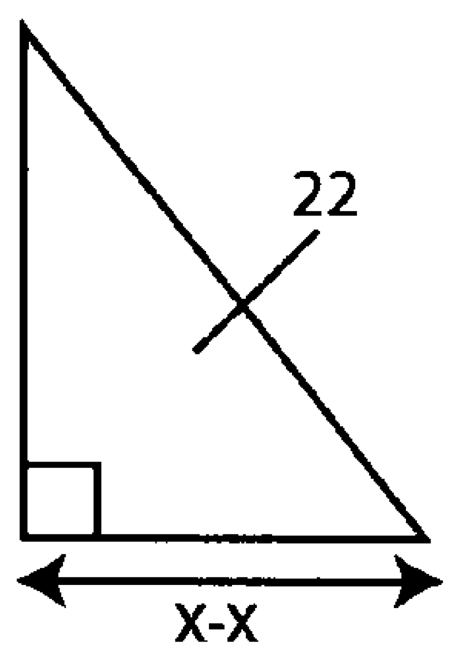


Figure 3b

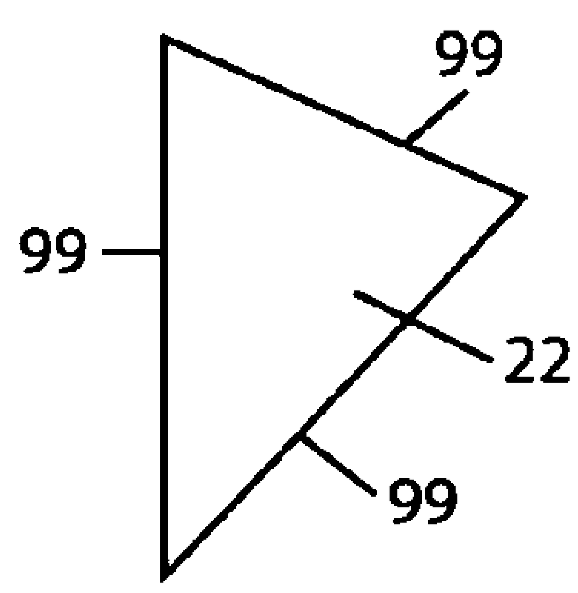


Figure 3c

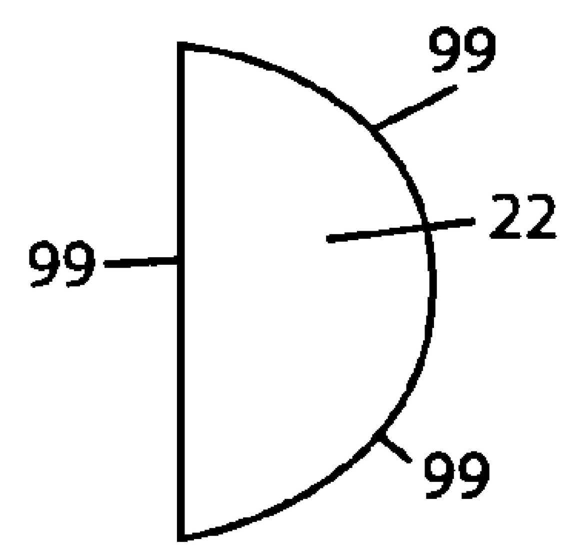


Figure 3d

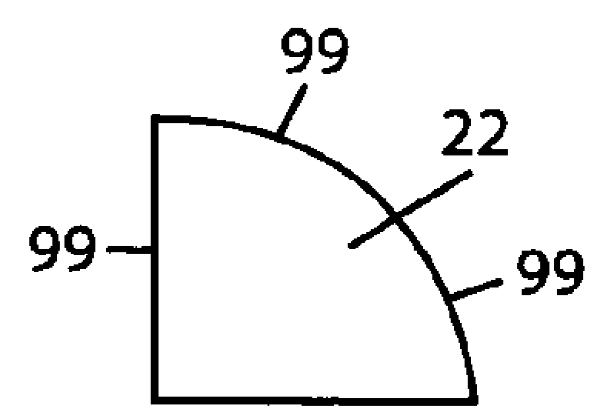


Figure 3e

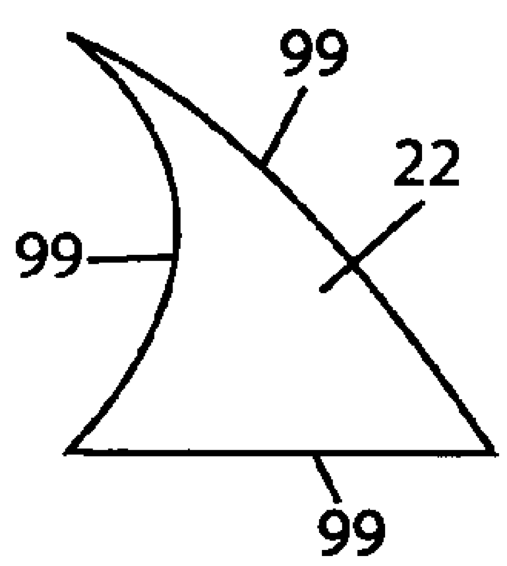


Figure 3f

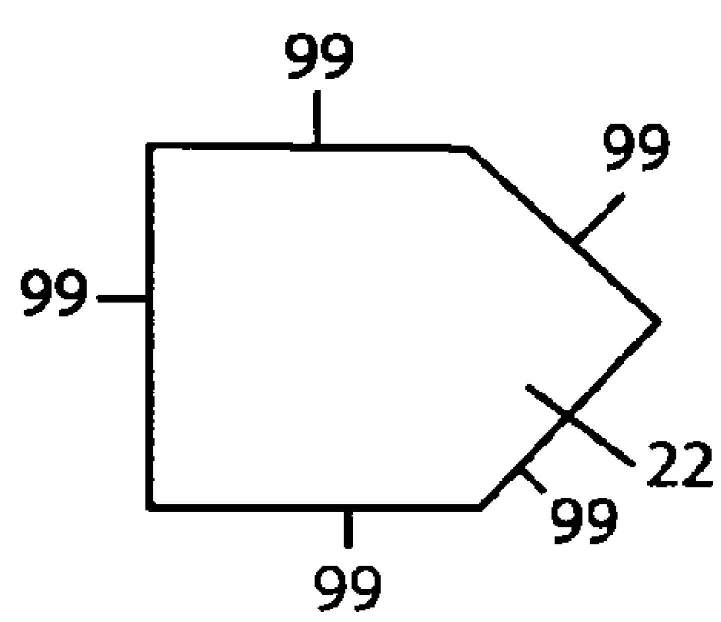


Figure 3g

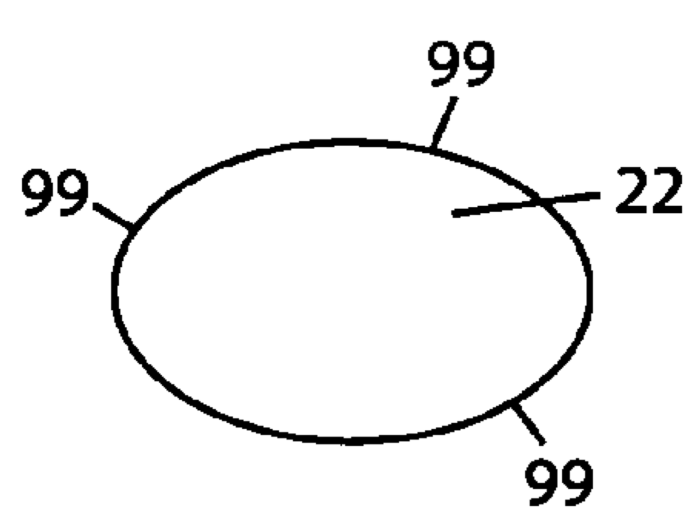


Figure 3h

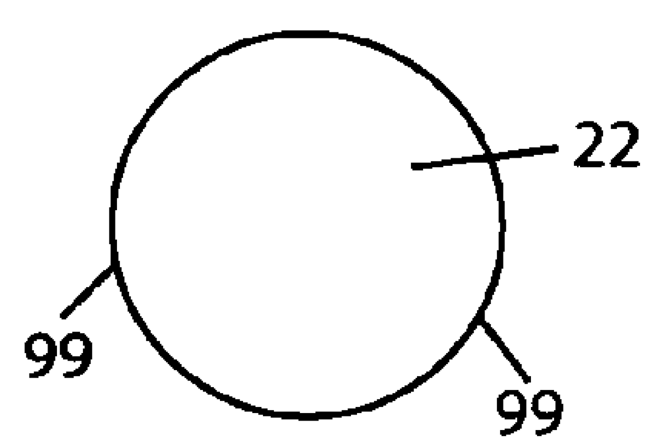


Figure 3i

60

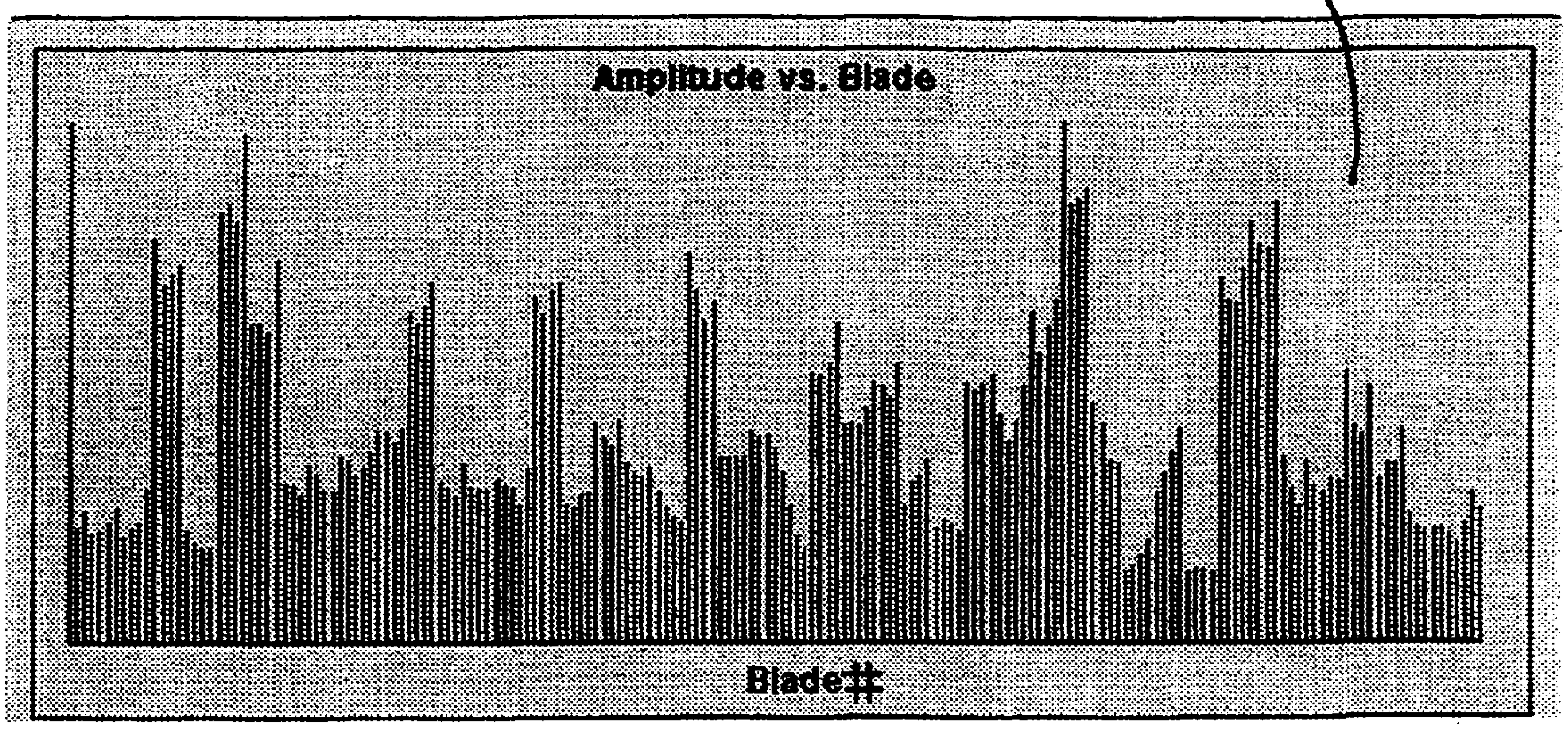


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Figure 4

TURBINE BLADE FOR MONITORING BLADE VIBRATION

FIELD OF INVENTION

The present invention relates generally to blade vibration monitoring and, more particularly, to blade vibration monitoring of a shrouded turbine blade.

BACKGROUND OF INVENTION

Turbo-machinery engines, such as combustion turbine engines, contain rotating blades in a compressor section and rotating blades in a turbine section. The blades are generally arranged circumferentially in rows with each row being comprised of a plurality of blades. Typical geometries include free standing blades (i.e. blades that do not contact adjacent blades) or shrouded blades (i.e. blades that do contact adjacent blades).

During normal engine operation, the rotating blades are exposed to excitation due to dynamic conditions in the engine such as flow induced vibration and nozzle effects. These dynamic conditions can lead to blade vibration, which is an appreciable cause of excitation failure in turbo-machinery.

A known means to avoid excitation failure is by monitoring operating blade vibration using a combination of strain gauges, non-contact capacitance probes, or optical probes to measure the vibration. However, such monitoring and evaluation is both costly and time inefficient.

Another known method involves a target painted on top of a blade shroud. However, these painted targets are problematic because they cannot detect motion in all directions. More specifically, blade tip motion parallel to the detecting edges of the target cannot be discerned.

Although several techniques exist for vibration measurements of rotating bladed-disk assemblies, no technique provides a suitable description of the dynamic behaviour. Therefore, there exists a need in the field of technology of turbo-machinery for a method and device that can accurately, easily, and/or efficiently measure and monitor rotating blade vibration.

SUMMARY OF INVENTION

The present invention provides a system for monitoring rotating blade vibration, comprising a blade, a target with a first indicating edge and a second indicating edge, the first and second indicating edges being nonparallel and arranged on top of the blade, a receiving device adapted to receive data about the target, and a processor that interprets the received data or information from the receiving device.

The present invention also provides a blade adapted for measuring blade vibration, comprising, a root portion, a platform portion, an airfoil portion, and a target with a first indicating edge and a second indicating edge, the first indicating edge and the second indicating edge being non-parallel.

Furthermore, the present invention provides a method for monitoring vibration of a blade, comprising, connecting a target to a blade tip, passing the target through a first transmission signal field of a transmission device at a fist moment in time, reflecting the transmission signal from the target to a receiver at a second moment in time, and processing the first and second received signals.

BRIEF DESCRIPTION OF THE DRAWINGS

The above mentioned and other concepts of the present invention will now be described with reference to the drawings of the exemplary and preferred embodiments of the present invention. The illustrated embodiments are intended to illustrate, but not to limit the invention. The drawings contain the following figures, in which like numbers refer to like parts throughout the description and drawings and wherein:

FIG. **1** is a perspective view of a section of a row of shrouded turbine blades operatively connected to the monitoring system of the present invention,

FIG. **2***a* is a perspective view of a shrouded blade tip with a target on the shroud,

FIG. **2***b* is a perspective view of a free standing blade tip with the target on the blade tip,

FIG. **2***c* is a perspective view of a shrouded blade tip with a target on the shroud and showing a plurality of receivers,

FIG. **3***a* is a plan view of the target on a shroud section at a first moment in time and the displaced target on a displaced shroud at a second moment in time,

FIG. **3***b*-**3***i* are plan views of exemplary target geometries, and

FIG. **4** is an exemplary computer screen display of processed information obtained from the monitoring system.

DETAILED DESCRIPTION OF INVENTION

The monitoring system **10** described herein employs some basic concepts. For example, one concept relates to a monitoring system **10** that measures the frequency and amplitude of turbine blade **17** vibration, and monitors the vibration of the turbine blade **17**. Another concept relates to a turbine blade **17** adapted for used with the monitoring system **10**. Yet another concept relates to the processing of turbine blade **17** vibration signal information into usable computer output **60**.

The present invention is disclosed in context of use as a monitoring system **10** within a combustion turbine engine for monitoring vibration of rotating turbine blades **17**. The principles of the present invention, however, are not limited to use within combustion turbine engines or to monitor vibration of rotating turbine components. For example, the monitoring system **10** can be used in other operational monitoring environments to measure blade turbine **17** vibration, such as steam turbines, aero-thermal aircraft engines, electric generators, air or gas compressors, auxiliary power plants, and the like. Also, while the system **10** is described in context of use as a monitoring system **10** it is not limited to use as a monitoring system **10**. For example, it can be used to obtain frequency and amplitude of blade **17** vibration for verification of analytic models and analysis of the turbine blades **17**. One skilled in the art may find additional applications for the apparatus, processes, systems, components, configurations, methods and applications disclosed herein. Thus, the illustration and description of the present invention in context of an exemplary combustion turbine engine for monitoring vibration of rotating turbine or compressor components is merely one possible application of the present invention. However, the present invention has particular applicability for use as a monitoring system **10** for monitoring vibration of turbine components.

To assist in the description of the claimed invention and its operation, the following coordinate system is introduced. The X-X axis **44** defines the axial direction and extends in the direction of the rotor centerline. Axis Y-Y **46** defines the radial direction and extends radially in a radial plane that is perpendicular to the axial direction and outward through the blade **17**. The Z-Z axis **48** defines the tangential direction and extends in the above radial plane being orthogonal to both the X-X axis **44** and Y-Y axis **46** and in the direction of rotation.

Two directions of vibration that the monitoring system **10** can measure and detect are the tangential and axial components of vibration. As one skilled in the art will recognize, these directions of vibration describe two fundamental blade modes. The tangential vibratory motion is determined by monitoring blade tip **28** motion in the Z-Z direction **48** and the axial vibratory motion is obtained by monitoring blade tip **28** motion in the X-X direction **44**.

Components

Referring to FIG. **1**, an exemplary monitoring system **10** adapted to monitor turbine blade **17** vibration is provided. The monitoring system **10** advantageously comprises a light beam **20** transmitted by a laser **16** and directed toward an optically reflective target **22** located on the shroud **14** of a turbine blade **17**. As the target **22** moves through the light beam field **20**, the light beam **20'** is reflected back to a receiver **50** which then sends the reflected light beam **20'** data to a processor **18**. From the light beam data **20**, **20'**, the processor **18** calculates the frequency, amplitude, and phase of vibration of the blade **17** as will be discussed in greater detail below. The processed information can then be viewed on a computer screen **40** using conventional computer program applications and/or saved.

Still referring to FIG. **1**, a turbine blade **17** of the present invention is preferably comprised of four sub components: a blade root **80**, a platform **81**, an airfoil **12**, and a shroud **14**. The blade root **80** connects the blade **17** to the rotor **70** and may provide a conduit to transfer cooling flow from the rotor **70** to the blade **17**. The platform **81** provides a transition from the blade root **80** to the blade airfoil **12**. The platform also transfers cooling air from the blade root **80** to the blade airfoil **12**. The platform **81** advantageously provides sealing between the combustion gas traversing the gas path and the cooling fluid in the rotor disk cavity **82** and can damp vibration for the bladed disk **90** system. The blade airfoil **12** directs the working fluid that creates a change in fluid momentum that causes the rotor **70** to rotate. The shroud **14** is located on top of the blade airfoil **12** at the blade tip **28** and is preferably integral to the blade airfoil **12**. The shroud **14** also functions as a seal preventing leakage of the hot combustion gas over the shroud **14** and into the cylinder **42**. Free standing blades **29** are conventionally distinguished from shrouded blades in that they do not have a shroud **14**. Turbine blades **17** are typically monolithic structures fabricated or cast from metallic material such as super-alloys or ceramic materials such as ceramic matrix composites.

As shown in FIGS. **2***a* and **2***b*, the monitoring system **10** can be used with free standing blades **28** as well as shrouded blades **17**. If a shrouded blade **17** is used, typical arrangements include multiple blades **12** grouped by a single shroud segment **14**, as well as integrally shrouded blades **17**. If an integrally shrouded blade **17** arrangement is used, each blade **12** advantageously has an individual portion of shroud **14** operatively connected to adjacent blade shrouds **15**.

Referring back to FIGS. **1** and **2**, a transmitter **16** generates a field through which the target **22** passes. The term “field” refers to the phenomenon generated by the transmitter **16**. For example, if a laser **16** is used as the transmitter **16**, the field is a light beam **20**. Likewise, if a magnet **16** is used as the transmitter **16**, the field is the magnetic field generated by the magnet **16**. For another example, if a radar **16** is used as the transmitter **16**, the field generated can be a microwave or any other electromagnetic wave.

In addition to the active transmitters described above, a transmitter free passive infra-red (IR) systems that function only as a receiver can also be employed to detect a change in the emission of thermal IR radiation as the probe focal point (detection spot) passed over the shroud **14** or target **22** surface. A target **22** used with a passive receiver is generally designed to emit less IR because the target is constructed from a material having a low emissivity.

The illustrated transmitter **16** is embodied as an external laser and produces a light beam **22** of a suitable wavelength, preferably in the infrared band and at a few hundreds of milliwatts to produce a relatively small and intense spot on the shroud. A suitable laser **16** is commercially available from Agilis, West Palm, Fla. and as part number PC28-13G. However, as will be appreciated by those skilled in the art, other suitable transmitters **16** can be used.

If a laser is used as the transmitter, the laser **16** advantageously generates and projects a light beam **20** toward the blade shroud **14** or blade tip **28** if used with a free standing blade **29**. The laser **16** may generate and emit the light beam **20** continually, randomly, intermittently, graduated, or otherwise, although continuous emission is preferred for a more robust monitoring of the turbine blades **17**. A light beam **20** with a smaller diameter is preferred because it **20** responds most quickly to the arrival of the first indicating edge (e.g. arriving edge) **38** and departure of the second indicating edge **32** (e.g. departing edge) as the spot transits the target **22**, as well as having increased light spot intensity, thus improving the accuracy of the measurement of blade tip **28** displacement and provides for more precise detection of the arrival of the first **38** and departure of the second **32** indicating edges of the target **22**.

The receiver **50** receives the reflected field **20'** and converts the reflected field **20'** to a useable electrical signal and is sent to the processor **18**. If the field **20** is a light beam **20**, the receiver **50** can detect a reflected light beam **20'**. If the field **20** is a magnetic field **20**, the receiver **50** should detect a perturbation in this beam **20'** produced by the target **22** on the shroud **14**. If the field **20** is a microwave **20**, receiver **50** can detect a reflected microwave. However, as would be appreciated by those skilled in the art, other suitable receivers **50** are acceptable such as magnetic receivers **50** or microwave receivers **50**. If the receiver is used to detect a reflected light beam **20'**, a plurality of receivers **50** arranged to at least partially surround the laser **16** is preferably used to increase the likelihood of reflected field detection although there is no requirement to use a plurality of receivers or to arrange the receivers in a particular pattern. The transmitting device **16** may also function as the receiver **50**.

As shown in FIG. **2***a*, the target **22** is adapted to pass through the field **20** generated by the transmitter **16** and reflect a portion of the field **20'** back toward the receiver **50** or otherwise alter the transmitted field. Referring to FIG. **3***a*, the target **22** has two nonparallel edges **32**, **38** that allows for detection of linear motions of the shroud **14** parallel to X-X axis **44** and Z-Z axis **48**. The target **22** edge or edges are formed by the target **22** perimeter which defines its physical shape. For example, if the target is comprised of one or more linear segments then edges are formed by the linear segments. Thus if the target is a triangle (See FIG. **3***a*), then three edges are respectively formed by the three sides of the triangle. For another example, if the target is comprised of one or more arcuate segments then edges are formed by one or more portions of the arcuate segments. Thus if the target is an oval (See FIG. **3***h*), then one or more edges may be formed along the arc bounded by the major axis and one or more of edges may be formed along the arc bounded by the minor axis. Of course, the target may comprise both linear and arcuate portions, and thus have a both linear-based edges and arcuate-based edges.

The target **22** is preferably triangular, more preferably right triangular, in shape since triangles have the minimum number of edges that can be geometrically configured with at least two non parallel edges **32**, **38**. Reducing the number of edges minimizes the processing of extraneous information since only non parallel edge **32**, **38** data needs to be collected in order to determine the blade **17** vibration. However, there is no requirement that the target **22** be triangular in shape and FIGS. **3***b*-**3***g* provide some suitable exemplary configurations comprising at least two non parallel edges **99**. Targets **22** having straight indicating edges **99** provide a vibration measurement independent of the axial position of the transmitter **16** relative to the axial position of the shroud **14**. This relative offset between transmitter **16** and shroud **14** can be up to several inches in length when used in large turbines, preferably approaching 0.5 inch.

The target **22** advantageously reflects the transmitted field **20** toward the receiver **50**. If the transmitter **16** is a laser **16**, the target can be made of a reflective paint, tape, plate, ceramic, and the like. If the transmitting device **16** is a magnetic transmitter **16**, the target **22** can be made of a ferrous material capable of reflecting the magnetic field **20'** toward the receiver **50** or otherwise altering **20'**. If a microwave transmitter is used, target **22** can be made of a material that reflects the microwave field **20** toward the receiver **50**, reduces such reflection, or changes the phase of the reflected field **20'**. Referring to FIG. **2***b*, if the target **22** is placed on the blade tip **28** of a free standing blade **29**, the size of target **22** may be limited to fit onto the blade tip **28** since the free standing blade **29** tips **28** tend to be relatively thin in the Z-Z **48** direction.

Referring again to FIG. **1**, a rotation monitoring device **72** is advantageously attached to the rotor **70** or other suitable location, to count the number of rotor **70** revolutions. Such devices **72** may perform the counting function based upon optics, magnets, physical contact, other phenomenon and the like. A suitable optical rotation monitoring device is available from the Motion Sensors, Inc. From the information collected from the rotation monitoring device **72**, each target **22** in the blade row **13** can be identified and associated with a particular blade **17** in the blade row **13**.

Referring back to FIG. **3***a*, the processor **18** is configured to compare the actual time the second indicating edge **32'** of the target **22** departs or exits the field **20** with the expected time that the second indicating edge **32** of the target **22** is expected to depart or exit the field **20** in the absence of vibration. The processor is also configured to compare the actual time the first indicating edge **38'** of the target **22** enters the field **20** with the actual time that the second indicating edge **32'** of the target **22** exited the field **20**. The processor **18** is further configured to calculate the blade **17** frequency, -amplitude, and phase of vibration based upon the above two measurements.

Method of Assembly

Referring again to FIG. **1**, the transmitter **16** of the monitoring system **10** may be mounted or installed within the cylinder wall of the inner cylinder **42** of a turbine generation. The transmitter **16** is advantageously located in the turbine wherever good transmission of the field **20** can be obtained. In the illustrated embodiment, the laser **16** is configured as part of a probe system having an external laser and produces a light beam **22** of a suitable wavelength is located in the inner cylinder wall **42** above the shroud **14** directed toward the blade **13** row to be monitored. However, the main requirement to be maintained is that the laser **16** transmits the light beam **20** and receives the reflected light beam **20'**. Other locations are suitable, for example, any stationary component that offers a line of sight to the target **22** is acceptable. Furthermore, if the transmitter **16** is a laser **16**, optical devices such as mirrors, lenses, fiber optic leads, and the like may be used from a remote location to aim and guide the light beam **20** to the target as well as receive the reflected beam **20'**. In the illustrated embodiment, the laser **16** is located above the blade tip **28** oriented to point at the target **22**. Additionally, a fiber optic cable may be used to carry and direct the light beam **20** to the target **22**. As one skilled in the art would recognize, fiber optics lens such as a GRIN (gradient index) assembly may be used in conjunction with the fiber optic cable.

In the illustrated embodiment, the target **22** is oriented on the shroud **14** of a blade **17** with the base portion **32** of the triangle approximately parallel with the X-X axis **44**. The portion of the right triangle perpendicular **34** to the base portion **32** is arranged approximately perpendicular to the X-X axis **44** and in the Z-Z direction **48**. The length of the base portion **32** and the portion perpendicular **34** to the base portion can be adjusted to create a triangle hypotenuse **38** at the appropriate inclination. The basis of the measurement of the frequency and amplitude of blade vibration is determined from the difference in line length L**1** **36** of the non displaced shroud **14** as compared to the displaced line length L**2** **36'** that results from the displaced target **22'** on the displaced shroud **14'** and is discussed in more detail below. The target **22** has a first indicating edge **38**, **38'** and a second indicating edge **32**, **32'**. As also indicated, the first indicating edge **38**, **38'** and the second indicating edge **32**, **32'** are non-parallel. The first indicating edge **38**, **38'** and the second indicating edge **38**, **38'** are identified by the direction of rotation **85** of the turbine shaft **70**.

The target **22** is operatively connected with the blade **17**. For example, the target **22** can be mounted on the shroud **14** or blade tip **28**, painted the shroud **14** or blade tip **28**, in contact with the blade **17**, or attached to the blade **17**. The means of connecting the target **22** with the blade **17** is in part a function of the field type generated by the transmitter **22**. For example, if the transmitter **16** is a laser **16**, the target **22** would be painted, sprayed, or mounted on the shroud **14** or blade tip **28**. Alternatively, if a magnet **16** or microwave **16** is used as the transmitter, the shroud **14** would be advantageously adapted to reflect or otherwise alter, the field **20'** by placing a groove or other suitable depression in the body of the shroud **14**. The depression in the shroud **14** is necessary because of the nature of the field **20** generated by a magnetic transmitter **16** and a microwave transmitter **16**. The depression or groove will closely match the exterior dimension and contour of the shroud **14** and can be formed into the shroud **14** in the shape of the target **22**. If the blade **17** is produced from a nonferrous material, such as titanium, and the transmitter **16** is a magnet **16**, then a target **22** capable of reflecting, or otherwise altering, the magnetic field **20'** may be inserted in the shroud **14** depression. Moreover, the target **22** can be directly connected to the blade **17** or indirectly connected to the blade **17** via an interconnection. Suitable direct connections include, but are not limited to, adhesives, bolts, weldments, combinations thereof, and the like. Suitable interconnections include, but are not limited to a connective layer, an insulating layer, a damper, combinations thereof, and the like. However, as one skilled in the art will appreciate, the direct and indirect connections can be achieved in other ways to operatively associate the target **22** with the blade **17**.

Method of Operation

In operation, as illustrated, after the monitoring system **10** is initiated, the laser **16** generates the light beam **20** that is transmitted toward the blade shroud **14**. The transmitted light beam **20** creates a light spot on the shroud **14** that sweeps out a line **24** due to the rotation of the blades. The light spot functions as an indicator of the arrival and departure of the target **22**. As the turbine blade **17** rotates in the Z-Z direction **48**, the target **22** passes through the light beam **20** field and reflects at least a portion of the light beam field **20'** back towards the receiver **50**. The receiver **50** converts the reflected light beam **20'** to a signal that is sent, by a suitable means such as telemetry, optical fiber, or wire, to the processor **18**. The receiver **50** detects the reflected light beam **20'** beginning when the first indicating edge **38'** of the target **22** enters the field **20** until the second indicating edge **32'** of the target **22** exits the field **20**.

If the blade **17** is vibrating in one of the two fundamental directions, the shroud **14** will be located at a different position in the X-X and Z-Z plane for each revolution of the rotor **70**. This is illustrated in FIG. **3***a* showing the shroud **14** and the displace shroud **14'**. Lengths L**1** **36** and L**2** **36'** are defined as the length of the light spot on the target **22** and the displaced target **22'** respectively. The length L**1** **36** is determined from the time at which the second indicating edge **32** departs the field **20** subtracted from the time at which the first indicating edge **38** of the target **22** enters the field **20**. Similarly, length L**2** **36'** is determined from the time at which the second indicating edge **32** leaves the field **20** subtracted from the time at which the first indicating edge **38** of the target **22** enters the field **20**. Thus, for example, if the blade is vibrating in the axial direction **44**, length L**1** **36** and length L**2** **36'** will be different and furthermore indicate the displacement of the target **22** in the X-X direction. Measurements over many revolutions of the shaft **70** thus produces a vibration wave of shroud **14** vibratory motion in the X-X direction. Vibration of the shroud **14** in the Z-Z direction has no affect on this differential time measurement. Likewise, if the blade **17** is vibrating in the tangential direction, Z-Z **48**, or has a component of vibration in the Z-Z direction **48**, the actual time the second indicating edge **32** leaves the field **20** is subtracted from a calculated of the second indicating edge **32**. Measurements over many revolutions of the shaft **70** thus produces a vibration wave of vibratory motion in the Z-Z direction **48**. The time at which the first indicating edge **38** of the target **22** enters the field **20** is not used in this measurements. Vibration of the shroud in the X-X direction **44** has no affect on this arriving time measurement.

The processor **18** then interprets the time sequences from the reflected light beam **20'** accurately measured over an extended number of revolutions of the shaft **70**. The processor **18** can convert time differences into displacements given the frequency of a suitable high frequency clock, preferably greater than 100 MHz, the rotation speed of the shaft **70**, and radial (Y-Y direction **46**) distance of the shroud **14** from the X-X axis **44**. The processor **18** computes the frequency, amplitude, and phase of vibration of the rotating blade **17** from the sequence of time signals sent from the receiver **50** as described above. For example, an increase or decrease in the signal duration of the reflected light beam **20'** enables displacement measurements in the X-X direction **44** and a deviation from the expected time of arrival of target **22** edge **32** indicates a displacement of the blade tip **28** in the Z-Z direction. Thus, the change in signal duration of the reflected light beam **52** and time of arrival of edge **32** compared to an expected value can be converted to a monitoring signal **60** on a visual display monitor **40**. The two separately measured and orthogonal X-X and Z-Z displacements can be analyzed separately or combined into a single orbit of the blade's motion. A Fourier, or other suitable analysis of this signal provides the amplitude, frequency and phase of the vibration of blade **17** and all other blades in the row. Data can be interpreted and stored by the processor **18** in real time (i.e. instantaneously) or non real time (i.e. any time period greater than real time).

The processor **18** the outputs the calculations output in a form that suitably displays the processed information. A graphical output **40** advantageously allows the data **60** to be displayed in a user friendly fashion, such as a graph. Alternatively, the data **60** could be stored separately and used with a suitable program or database and analyzed at a later date. Lastly, the data **60** could be used and compared to other data **60** for the purpose of determining trends in the systems being monitored.

Although the illustrated embodiment shows the target **22** placed on each shroud **14** segment, the target **22** need not be placed on the shroud **14** of each blade **17** in the blade row **13**. Rather, multiple blades **17** in the blade row **13** may be have a single target **22**. However, because of geometric variances of the blades **17**, placing a target **22** on the shroud **14** of each blade **17** in the blade row **13** will provide more accurate results. Additionally, the shrouded blade **17** permits placement of a larger target **22** improving the ability to more accurately measure blade tip **28** motion.

While the preferred embodiments of the present invention have been shown and described herein, it will be obvious that such embodiments are provided by way of example only. Numerous variations, changes and substitutions will occur to those of skill in the art without departing from the invention herein. Also, one or more aspects or features of one or more embodiments or examples of the present invention may be used or combined with one or more other embodiments or examples of the present invention. Accordingly, it is intended that the invention be limited only by the spirit and scope of the appended claims.

The invention claimed is:

1. A system for monitoring rotating blade vibration, comprising:
- a blade;
- a target with a first indicating edge and a second indicating edge, the first and second indicating edges being non-parallel and arranged on top of the blade;
- a receiving device adapted to receive data about the target to calculate an amplitude or phase of an axial or tangential mode of vibration; and
- a processor that interprets the received data or information from the receiving device over many revolutions of the blade to determine a vibration wave of vibratory motion of the blade.

2. The system as claimed in claim **1**, wherein the receiving device transmits a field.

3. The system as claimed in claim **1**, further comprising a transmitting device that generates a field that the target passes through.

4. The system as claimed in claim **3**, wherein the transmitting device is selected from the group consisting of: a laser, a magnetic sensor, a microwave transmitter, and combinations thereof.

5. The system as claimed in claim **1**, wherein the target geometry has two non-parallel edges.

6. The system as claimed in claim **5**, wherein the target geometry is a triangle.

7. The system as claimed in claim **6**, wherein the target geometry is a right triangle.

8. The system as claimed in claim 1, wherein the target is painted on a tip or shroud of the blade.

9. The system as claimed in claim 1, wherein the target is a fired ceramic coating on the tip or shroud of the blade.

10. The system as claimed in claim 1, wherein the target is adapted to reflect a laser beam.

11. The system as claimed in claim 1, wherein the target is located on a single blade.

12. The system as claimed in claim 1, wherein the target is located on a plurality of blades.

13. The system as claimed in claim 1, wherein a laser is surrounded by a plurality of receivers.

14. The system as claimed in claim 1, wherein the sensor is located above the target.

15. The system as claimed in claim 1, wherein a frequency, amplitude, and phase of an axial or tangential mode of vibration is calculated.

16. The system as claimed in claim 1, wherein a combined axial and tangential mode of vibration is calculated.

17. The system as claimed in claim 1, wherein the axial mode of vibration is individually calculated or the tangential mode of vibration is individually calculated.

18. The system as claimed in claim 1, wherein the amplitude or phase is the amplitude or phase of only the axial component of vibration and having no tangential component.

19. The system as claimed in claim 1, wherein the amplitude or phase is the amplitude or phase of only the tangential component of vibration and having no axial component.

20. A blade adapted for measuring blade vibration, comprising:

a root portion;

a platform portion;

an airfoil portion; and

a target with a first indicating edge and a second indicating edge, the first indicating edge and the second indicating edge being non-parallel,

wherein a vibration wave of vibratory motion of the blade including an amplitude or phase is determined over many revolutions of the operating blade.

21. The blade as claimed in claim 20, wherein the blade is a shrouded blade.

22. The blade as claimed in claim 21, wherein the shroud is adapted to support a target.

23. The blade as claimed in claim 21, wherein the target has two non-parallel edges.

24. The blade as claimed in claim 21, wherein the target has the shape of a right triangle.

25. The blade as claimed in claim 20, wherein the amplitude or phase is the amplitude or phase of only the axial component of vibration and having no tangential component.

26. The blade as claimed in claim 20, wherein the amplitude or phase is the amplitude or phase of only the tangential component of vibration and having no axial component.

27. A method for monitoring vibration of a blade, comprising:

connecting a target to a blade tip;

passing the target through a first transmission signal field of a transmission device at a first moment in time;

reflecting the transmission signal from the target to a receiver at a second moment in time; and

processing the first and second received signals over many revolutions of the blade to obtain a vibration wave of vibratory motion of the blade.

28. The method as claimed in claim 27, wherein a frequency, amplitude, or phase of an axial or tangential mode of vibration is determined.

29. The method as claimed in claim 27, wherein a combined axial and tangential mode of vibration is determined.

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